Air Pollution Removal

Summary

The Air Pollution Removal program is based on research conducted by David Nowak, Ph.D., of the USDA Forest Service. Dr. Nowak developed a methodology to assess the air pollution removal capacity of urban forests with respect to pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10). Pollution removal is reported on an annual basis in pounds and U.S. dollars.

Dr. Nowak estimated removal rates for 10 cities: Atlanta, Georgia; Austin, Texas; Baltimore, Maryland; Boston, Massachusetts; Denver, Colorado; Milwaukee, Wisconsin; New York, New York; Philadelphia, Pennsylvania; St. Louis, Missouri; and Seattle, Washington. CITYgreen can determine which of those cities is nearest the site, or the user can manually identify the city nearest to the area being analyzed and use its results.. Or, the user can average results from all 10 cities.

The program estimates the amount of pollution being deposited within a certain given study site based on pollution data from the nearest city then estimates the removal rate based on the area of tree and/or forest canopy coverage on the site.

Technical Methodology

The methodology determines a pollutant removal rate, or flux (F), by multiplying the deposition velocity (V_d) by the pollution concentration (C).

$$F \ (g/cm^2/sec) = V_d(cm/sec) \ x \ C \ (g/cm^3)$$

The pollutant flux is then multiplied by the size of the area during periods in which the pollutant is known to exist there. This makes it possible to estimate the total pollutant flux for that surface by the hour. Hourly fluxes can be summed to estimate daily, monthly, or yearly fluxes.

Air pollution estimates generated from CITYgreen currently are designed for urban and suburban forests. Therefore, CITYgreen analyses run on rural sites that are far removed from cities may overestimate tree benefits.

References:

Atlanta, GA: Nowak, D.J. and Crane, D.E. 2000. The Urban Forest Effects (UFORE) Model: quantifying urban forest structure and functions. In M. Hansen and T. Burk, eds. Proceedings: Integrated tools for natural resources inventories in the 21st century. IUFRO Conference, 16-20 August 1998, Boise, ID; General Technical Report NC-212, U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, MN. pp. 714-720.

Austin, TX: Methodology and models from "Nowak and Crane." City-specific data produced for AMERICAN FORESTS.

Baltimore, MD: Nowak, D.J. and Dwyer, J.F. 2000. Understanding the benefits and costs of urban forest ecosystems. In J. Kuser, ed. Urban and Community Forestry in the Northeast. New York: Plenum Publishing pp 11-25; Nowak and Crane.

Boston, MA: Nowak and Dwyer.

Denver, CO: Unpublished USDA Forest Service data, Northeastern Research Station, Syracuse, NY.

Milwaukee, WI: Methodology and models from "Nowak and Crane." City-specific data produced for AMERICAN FORESTS.

New York, NY: Nowak and Dwyer; Nowak and Crane.

Philadelphia, PA: Nowak and Dwyer.

St. Louis, MO: Unpublished USDA Forest Service data, Northeastern Research Station, Syracuse, NY.

Seattle, WA: Methodology and models from "Nowak and Crane." City-specific data produced for AMERICAN FORESTS.

Notes: Austin SO_2 and NO_2 data were taken from Houston and may not represent actual conditions in Austin. Austin was missing O_3 concentration data for January, February, and December. Concentration data for these months were estimated based on average national O_3 concentration trend data.

Carbon Storage and Sequestration

Summary

CITYgreen's carbon module quantifies the role of urban forests in removing atmospheric carbon dioxide and storing the carbon. Based on tree attribute data on trunk diameter, CITYgreen estimates the age distribution of trees within a given site and assigns one of three Age Distribution Types. Type I represents a distribution of comparatively young trees. Type 2 represents a distribution of older trees. Type 3 describes a site with a balanced distribution of ages. Sites with older trees (with more biomass) are assumed to remove more carbon than those with younger trees (less biomass) and other species. For forest patches, CITYgreen relies on attribute data on the dominant diameter class to calculate carbon benefits.

Each distribution type is associated with a multiplier, which is combined with the overall size of the site and the site's canopy coverage to estimate how much carbon is removed from a given site. The program estimates annual sequestration, or the rate at which carbon is removed, and the current storage in existing trees. Both are reported in tons. Economic benefits can also be associated with carbon sequestration rates using whatever valuation method the user feels appropriate. Some studies have used the cost of preventing the emission of a unit of carbon—through emission control systems or "scrubbers," for instance—as the value associated with trees' carbon removal services.

Technical Methodology

Estimating urban carbon storage and sequestration requires the study area (in acres), the percentage of crown cover, and the tree diameter distribution. Multipliers are assigned to three predominant street tree diameter distribution types:

Distribution Types	Carbon Storage Multipliers
Type 1 (Young population)	0.3226
Type 2 (Moderate age population, 10-20 years old)	0.4423
Type 3 (Even distribution of all classes)	0.5393
Average (Average distribution)	0.4303

Distribution Types	Carbon Sequestration Multipliers
Type 1 (Young population)	0.00727
Type 2 (Moderate age population, 10-20 years old)	0.00077
Type 3 (Even distribution of all classes)	0.00153
Average (Average distribution)	0.00335

CITYgreen uses these multipliers to estimate carbon storage capacity and carbon sequestration rates. For example, to estimate carbon storage in a study area:

Study area (acres) x Percent tree cover x Carbon Storage Multiplier = Carbon Storage Capacity

To estimate carbon sequestration:

Study area (acres) x Percent tree cover x Carbon Sequestration Multiplier = Carbon Sequestration Annual Rate

In recent studies conducted by Dr. David Nowak and Dr. Greg McPherson of the USDA Forest Service, it has been suggested that if urban trees are properly maintained over their lifespan, the carbon costs outweigh the benefits. Tree maintenance equipment such as chain saws, chippers, and backhoes emit carbon into the atmosphere. Carbon released from maintenance equipment and from decaying or dying trees could conceivably cause a carbon benefit deficit if it exceeds in volume the amount sequestered by trees.

To maximize the carbon storage/sequestration benefits of urban trees, the USFS suggests planting larger and longer-lived species in urban areas so that more carbon can be stored, mortality rates can be decreased, and maintenance methods can be revised over time as technology improves. For more information on how to estimate urban carbon storage and sequestration, please contact the USDA Forest Service (Northeastern Forest Experiment Station, Syracuse, New York).

References

1. Nowak, David and Rowan A. Rowntree. "Quantifying the Role of Urban Forests in Removing Atmospheric Carbon Dioxide." Journal of Arboriculture, 17 (10): 269 (October 1, 1991).

2. McPherson, E. Gregory, Nowak, David J. and Rowan A. Rowntree, eds. 1994. "Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project." Gen. Tech. Rep. NE-186. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.